Remarks

Rejection Pursuant to 35 USC 112

Claims 1 - 20 were rejected as being indefinite. Regarding claim 1, the Examiner contends that the phrase "nanocavity array", and "predetermined spectral response" render the claim indefinite because it is unclear what is "nanocavity" means. The Examiner argues that the claim does not recite laser structure, and therefore does not appear to understand how the claim can define a nanocavity. It is not clear to the Examiner how to lithographically form the nanocavity to define a predetermined spectral response of each nanocavity.

Language from claim 1 of U.S. Patent 6,466,709 has been incorporated into the preamble of claim 1 in response to the Examiner's suggestion to better provide a definition of the claimed cavity.

The term, "nanocavity array" is not literally used in claim 1. What is claimed is an improvement in a pumped multiwavelength photonic device. The device may be anyone of a number of different types of electrooptic photonic devices, including but not limited to a laser, modulator, detector, router, gate or spectrometer for wavelength and time division multiplexing applications. (Specification, page 9, line 21; page 10 lines 3 - 4). The improvement comprises a plurality of nanocavities. The plurality of nanocavities form a periodic patterned array of nanocavities. The applicants assume that the Examiner has no difficulty in understanding the general concept of a periodic patterned array of objects. A checkerboard is a patterned array of red and black squares. A dozen eggs for a

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patterned array of eggs in a carton. Atoms form a patterned array in a crystal and so forth. Here the plurality of nanocavities form a patterned array.

Fig. 1a of the specification shows a single defect nanocavity, or microcavity or simply cavity, which is identical to Fig. 3 in **Painter**. It should be transparently clear that what is being called a nanocavity in the present specification is identical to what was called a microcavity in the prior art. Thus, there can be no indefiniteness about what a nanocavity or cavity is in this context. An optical cavity is part of the operative combination of a laser and many other optical devices. Here the optical cavity is of the order of the wavelength of light, i.e. a microcavity or more properly a nanocavity since the dimensions of the cavities as in **Painter** are conveniently measured in nanometers, e.g. a mode volume of $30nm^3$ (page 8, line 2).

The Examiner states that he does not understand how to lithographically form the nanocavity to define a predetermined spectral response of each nanocavity. It is well known that an optical cavity in a laser significantly affects the mode of light which the laser produces. The nanocavities are described in the specification shown as omitted holes in an array of holes forming the photonic crystal, Fig. 1a and 1b and/or differently sized holes in the array, Figs. 6a – 6c, and/or filled holes in the array, (page 10, lines 7 – 14) and/or altered positions of holes in the array. Defects in the array affect that optical property of the array and define optical cavities of the size of the defect. See for example, page 3, line 14; page 5, line 21; page 6, line 10; page 7, line 10; page 8, lines 12 – 13; and page 9, line 12. This is also clearly taught by **Painter**. See also **Lin**

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et.al., "Direct Measurement of the Quality Factor in a Two-Dimensional Photonic-Crystal Microcavity," Optics Letters, Vol. 16, No. 23, (2001); **Zhou et.al.**, "Electrically Injected Single-Defect Photonic Bandgap Surface-Emitting Laser at Room Temperature," Electronics Letters, Vol. 36, no 18 (2000); **Joannopoulos et.al.**, "Tunable Microcavity and Method of Using Nonlinear Materials in a Photonic Crystal" U.S. Patent 6,058,127 (2000).

It cannot be sustained that "nanocavities", "microcavities" or "cavities" in semiconductor devices are not known, that how they are fabricated in the photonic crystal and how they affect the optical properties or spectral response of the semiconductor device is not readily understood.

Regarding claim 9, the Examiner contends that the word "modulator" renders the claim indefinite because it is unclear what is "modulator". The Examiner contends that claim fails to recite the structure of modulator. A modulator is a well known photonic device, which takes an input signal and modulates it with a modulating signal to produce an output signal which has a form which is the input signal modulated by the modulating signal. It is clear that all that is being claimed is that the improvement is being used in a modulator. What is being claimed is an improvement in optical cavities which are used in various photonic devices, which here are claimed to include modulators. It is not necessary to claim the structure of every modulator devisable in order to claim the use of the improvement in one of them.

Regarding claim 10, the Examiner next contends the phrase that the "crystal is formed in active quantum well photonic well material" renders the claim

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indefinite in that it is not clear to the Examiner how to form an active quantum well material. The applicants do not literally use the phrase, "active quantum well photonic well material." Again, what is an "active quantum well" is notoriously well known and how to form an array of holes in such material is clear, i.e. the same way in which the photonic crystal is formed in any material. The phrase "active quantum well" is used in a large number of Patents and literature references and the Examiner is directed to the following for various descriptions and examples of what is an "active quantum well":

	PAT. NO.	Title
1	6,628,686	Integrated multi-wavelength and wideband lasers
2	6,614,060	Light emitting diodes with asymmetric resonance tunnelling
3	6,570,898	Structure and method for index-guided buried heterostructure AlGaInN laser diodes
4	6,567,443	Structure and method for self-aligned, index-guided, buried heterostructure AlGaInN laser diodes
5	6,563,627	Wavelength converter with modulated absorber
6	6,541,831	Single crystal silicon micromirror and array
7	6,526,083	Two section blue laser diode with reduced output power droop
8	6,353,624	Semiconductor laser with tunable gain spectrum
9	6,304,587	Buried ridge semiconductor laser with aluminum-free confinement layer
10	6,271,526	Efficient radiation coupling to quantum-well radiation-sensing array via evanescent waves
11	6,238,944	Buried heterostructure vertical-cavity surface-emitting laser diodes using impurity induced layer disordering (IILD) via a buried impurity source
12	6,233,267	Blue/ultraviolet/green vertical cavity surface emitting laser employing lateral edge overgrowth (LEO) technique
13	6,194,240	Method for fabrication of wavelength selective electro-optic grating for DFB/DBR lasers
14	6,174,749	Fabrication of multiple-wavelength vertical-cavity opto-electronic device arrays
15	6,084,898	Laser devices including separate confinement heterostructure
16	5,965,899	Miniband transport quantum well detector

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17 5,963,568 Multiple wavelength, surface emitting laser with broad bandwidth distributed Bragg reflectors
18 5,956,568 Methods of fabricating and contacting ultra-small semiconductor devices
19 5,903,588 Laser with a selectively changed current confining layer
20 5,889,805 Low-threshold high-efficiency laser diodes with aluminum-free active region
21 5,863,809 Manufacture of planar photonic integrated circuits
22 5,828,684 Dual polarization quantum well laser in the 200 to 600 nanometers range
23 5,825,799 Microcavity semiconductor laser
24 5,799,026 Interband quantum well cascade laser, with a blocking quantum well for improved quantum efficiency
25 5,790,583 Photonic-well Microcavity light emitting devices
26 5,782,996 Graded compositions of II-VI semiconductors and devices utilizing same
27 5,745,517 Alternative doping for AlGaInP laser diodes fabricated by impurity-induced layer disordering (IILD)
28 5,742,077 Semiconductor device
29 5,699,375 Multiple wavelength, surface emitting laser with broad bandwidth distributed Bragg reflectors
30 5,659,179 Ultra-small semiconductor devices having patterned edge planar surfaces
31 5,648,979 Assembly of VCSEL light source and VCSEL optical detector
32 5,642,376 Visible light surface emitting semiconductor laser
33 5,629,215 Method of fabricating and contacting ultra-small three terminal semiconductor devices
34 5,608,753 Semiconductor devices incorporating p-type and n-type impurity induced layer disordered material
35 5,583,351 Color display/detector
36 5,574,745 Semiconductor devices incorporating P-type and N-type impurity induced layer disordered material
37 5,567,646 Method of making a stripe-geometry II/VI semiconductor gain-guided injection laser structure using ion implantation
38 5,534,444 Process for producing an electrically controllable matrix of vertically structured quantum well components
39 5,530,713 Strained layer InGaAs quantum well semiconductor laser on GaAs substrate with quantum well-barrier layer interface structure
40 5,521,398 Quantum well heterostructure optical operator
41 5,465,263 Monolithic, multiple wavelength, dual polarization laser diode

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arrays

42 5,455,429 Semiconductor devices incorporating p-type and n-type impurity induced layer disordered material

43 5,452,118 Optical heterodyne receiver for fiber optic communications system

44 5,434,700 All-optical wavelength converter

45 5,428,634 Visible light emitting vertical cavity surface emitting lasers

46 5,351,256 Electrically injected visible vertical cavity surface emitting laser diodes

47 5,344,746 Integrated light deflector and method of fabrication therefor

48 5,327,415 Integrated light deflector and method of fabrication therefor

49 5,325,386 Vertical-cavity surface emitting laser assay display system

50 5,287,376 Independently addressable semiconductor diode lasers with integral lowloss passive waveguides

Regarding claim 16, the Examiner contends that the phrase "means for changing optical or electrical properties of said nonlinear optical material" renders the claim indefinite because it is not clear how to provide optical or electrical *{sic – changes}*. Page 4, line 20 – 24 states:

> "The array further comprises means for changing optical or electrical properties of the nonlinear optical material in each of the nanocavities, such as electrodes for applying a voltage or current across the array. "

The means is enabled in the specification and the Examiner cannot as a matter of law use 35 USC 112 to reject a functionally defined means, which in pertinent part provides:

> "An element in a claim for a combination may be expressed as a means or step for performing a specified function **without the recital of structure, material, or acts in support thereof**, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof. " (emphasis added)

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Rejection Pursuant to 35 USC § 102

What **Painter** does not show is anything like Figs. 2a and 2b, which depict an array of nanocavities or microcavities or cavities. The Examiner repeats the earlier rejection that **Painter** discloses a single nanocavity or microcavity in a photonic crystal. It mischaracterizes **Painter** to assert that it teaches a periodic or patterned array of such nanocavities or microcavities in a photonic crystal. The holes are not the nanocavities or microcavities in this context. The holes in the semiconductor material define the photonic crystal and it is there presence that results in the *lack or absence of any nanocavity or microcavity in a photonic crystal.*

Painter is clearly lacking any disclosure whatsoever of forming a supercavity in a photonic device made from a periodic array of nanocavities.

Rejection Pursuant to 35 U.S.C. § 103

The Examiner repeats the earlier rejection of claims 6 and 15 as obvious over **Painter**. The mere knowledge that detectors exist as disclosed by **Tanguary, Jr** does not suggest or motivate creating an array of nanocavities in anything, including a detector.

Further claims 6 and 15 depend directly or indirectly on claim 1 and are allowable therewith and for the additional limitations set forth in the subject claims.

The Examiner deems the applicants prior arguments as unpersuasive in

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that definitions of various common elements in the electrooptical arts were not provided to the Examiner's satisfaction.

Although it is largely semantic, the applicants now claim merely "cavity" since the difference in this context of a cavity, microcavity or nanocavity is merely semantic. The reference in the patent literature to a cavity in a photonic crystal is notorious, and can be found in the literature references cited above and, for example, in the following patents:

PAT. NO.	Title	
1	6,640,034	Optical photonic band gap devices and methods of fabrication thereof
2	6,639,712	Method and apparatus for configuring and tuning crystals to control electromagnetic radiation
3	6,618,535	Photonic bandgap device using coupled defects
4	6,611,636	Hybrid active electronic and optical Fabry Perot cavity
5	6,611,085	Photonically engineered incandescent emitter
6	6,597,851	Periodic dielectric structure having a complete three-dimensional photonic band gap
7	6,597,721	Micro-laser
8	6,593,894	Highly directional receiver and source antennas using photonic band gap crystals
9	6,589,334	Photonic band gap materials based on spiral posts in a lattice
10	6,586,775	Light-emitting device and a display apparatus having a light-emitting device
11	6,583,350	Thermophotovoltaic energy conversion using photonic bandgap selective emitters
12	6,577,801	Holey optical fibers
13	6,570,704	High average power chirped pulse fiber amplifier array
14	6,569,382	Methods apparatus for the electronic, homogeneous assembly and fabrication of devices
15	6,567,209	Microcavity amplifiers
16	6,555,945	Actuators using double-layer charging of high surface area materials
17	6,547,982	Dielectric composites

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18	6,542,682	Active photonic crystal waveguide device
19	6,542,654	Reconfigurable optical switch and method
20	6,539,155	Microstructured optical fibres
21	6,532,326	Transverse-longitudinal integrated resonator
22	6,529,676	Waveguide incorporating tunable scattering material
23	6,515,305	Vertical cavity surface emitting laser with single mode confinement
24	6,512,866	High efficiency channel drop filter with absorption induced on/off switching and modulation
25	6,496,632	Method of fabricating photonic structures
26	6,468,823	Fabrication of optical devices based on two dimensional photonic crystal structures and apparatus made thereby
27	6,468,348	Method of producing an open form
28	6,466,709	Photonic crystal microcavities for strong coupling between an atom and the cavity field and method of fabricating the same
29	6,445,862	Dispersion compensating photonic crystal fiber
30	6,433,931	Polymeric photonic band gap materials
31	6,424,317	High efficiency broadband antenna
32	6,416,575	Photonic crystal multilayer substrate and manufacturing method thereof
33	6,404,966	Optical fiber
34	6,363,096	Article comprising a plastic laser
35	6,334,017	Ring photonic crystal fibers
36	6,330,259	Monolithic radial diode-pumped laser with integral micro channel cooling
37	6,310,991	Integrated optical circuit
38	6,274,293	Method of manufacturing flexible metallic photonic band gap structures, and structures resulting therefrom
39	6,260,388	Method of fabricating photonic glass structures by extruding, sintering and drawing
40	6,219,006	High efficiency broadband antenna
41	6,198,860	Optical waveguide crossings
42	6,175,671	Photonic crystal waveguide arrays
43	6,134,043	Composite photonic crystals
44	6,130,969	High efficiency channel drop filter
45	6,111,472	Quasi-optical amplifier
46	6,101,300	High efficiency channel drop filter with absorption induced on/off switching and modulation
47	6,097,870	Article utilizing optical waveguides with anomalous

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		dispersion at vis-nir wavelenghts
48	6,093,246	Photonic crystal devices formed by a charged-particle beam
49	6,075,640	Signal processing by optically manipulating polaritons
50	6,064,511	Fabrication methods and structured materials for photonic devices

The Examiner cites **Painter** as stating, "the ability to fabricate compact lateral *microcavities* is important" (p 1820, first paragraph, emphasis added). This is a passing, offhand statement in the grammatical plural as a rhetorical statement of importance and is not in any way a statement of what **Painter** did. One could similarly state that "cures to cancer are important", or "vacations in warm climates are popular", but it does not mean that the writer is speaking about more than one cure or vacation. The very sentence prior to the one upon which the Examiner relies to reject the claims states:

> "We describe initial experimental results of a type of microcavity laser in which light is confined to a single defect of a nanofabricated two-dimensional (2D) photonic crystal:"

If the light is confined to a **single defect** of a nanofabricated two-dimensional (2D) photonic crystal, it must be confined to a single microcavity, otherwise it would be confined to multiple defects and furthermore the multiple defects themselves would have to be organized to form patterned array of cavities, which in turn has an effect on the optical performance of the device, i.e. a higher order affect than just a single defect or microcavity. A fair reading of **Painter** clearly demonstrates that **Painter** does not contemplate forming multiple defects or cavities into a periodic pattern d array or supercavity collectively comprised of an

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array of nanocavities. A mere, bare statement about the importance of "microcavities" does not teach or disclose anything about how a plurality of microcavities can be used for any purpose, and specificially does not teach or disclose anything about supercavities or periodic patterned arrays of nanocavities.

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